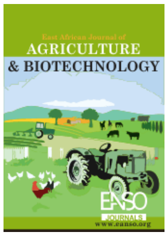

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Original Article

Climate-Smart Agriculture Practices and Small-scale Farmers' Income: The Case of Maize Farmers in Trans-Nzoia County, Kenya

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ABSTRACT

Climate-Smart Agriculture (CSA) is one of the resolutions that addresses the issues of climate change adaptation, mitigation and income of farmers. This study evaluated the adoption of CSA practices and the income of small-scale farmers in Trans-Nzoia County. A well-developed questionnaire was used to collect data. Multiple regression and descriptive statistics were applied to analyse the data collected from 119 randomly selected sample households. Findings revealed that the practices were at great extent, averagely, fairly, and poorly adopted by the farmers. Adoption of practices including water conservation structures, water harvesting, minimum tillage, integrated soil fertility management, agroforestry, drought tolerant crop varieties, timely planting, use of organic fertilizers, crop rotation, early maturing varieties and practice of irrigation were significant at 5% level of significance influence the income of small-scale farmers. This study therefore recommends that continuous promotion of climate-smart agriculture practices is important to increase farmers' productivity and therefore income increase. Strategies should be developed so that farmers' level of adoption of climate-smart agricultural practices increases so as to boost productivity and therefore increase the income of the farmers. Training farmers on the benefits of adoption of CSA practices while also subsidizing farm inputs like agro-chemicals and fertilizers can boost the adoption rate of CSA practices, resulting in high farm income.

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INTRODUCTION

Maize (Zea mays L.) is the second most important cereal crop and a staple food crop for millions of people across the world (Grote et al., 2021; Midamba, 2022). It is the source of protein, iron, vitamin B, minerals, and carbohydrate. Maize is of an important economic value among the population as every part is of an economic importance and can all be used to produce a large variety of food and non-food products in industries (Tanumihardjo et al., 2020). In Sub-Saharan Africa, is the most important cereal crop and a staple food for an estimated 50% of the population and is consumed in various ways among them; maize meal and porridge which are the top uses of maize (FAOSTAT, 2019). Comparably, in Kenya maize is ranked as the first important food crop and over 90% of the population consumes it as a staple food (Wotia & Omukunda, 2021). Further maize is very vital feed for livestock and is processed in industries to produce oil and starch. Maize is produced by both smallholder and large-scale farmers, however, smallholders who depend on agriculture for income are the major producers of maize in the country though these farmers have limited resources to invest in agricultural practices which often compromise their crop production leading to food insecurity in the country (Mumo et al., 2021).

The largest maize producing counties in the country are Nakuru, Uasin and Gishu Trans-Nzoia and the total land area under maize production is about 1.5 million hectares, with an annual average production estimated at 3.0 million metric tons, giving a mean yield of 2 metric tons per hectare nationally (FAOSTAT, 2019). Of the total annual maize production, Trans-Nzoia County contributes 5.4 million bags making it a significant contributor to the country's food security (Mang'eni, 2022). The yields range from 4 to 8 T/Ha in the high potential highlands areas, representing only 50% or even less of the genetic potentials of the hybrids (KNBS, 2019). Maize grows well across a range of agro-ecological zones with a wide range of tolerance to temperature conditions (Nassary et al., 2020). It is essentially a crop of warm regions where moisture is enough and requires an average daily temperature of at least 20°C for proper growth and development (Krell et al., 2021). The optimum temperature for good yields is around 30°C and a large number of the varieties differ in maturity period and are more so sensitive to moisture stress around the time of tasselling and during cob formation (Kwena et al., 2021). It also needs optimum moisture conditions at the time of planting. Maize grows well with 600-900 mm of rainfall, which should be well distributed throughout the growing period (Omondi et al., 2021).

Despite the benefits of maize as an important staple food crop among many communities in the country, the production is low as compared to the potential that the country has, with production as low as 1.0-ton ha^{-1} against the potential of 6–8-ton ha^{-1} (Keno et al., 2018; Kim et al. 2019; Maitra et al. 2021; Worku et al., 2020). Factors contributing to low maize production are soil infertility, lack of soil water conservation practices, lack of inputs [fertiliser, improved seed], irrigation water stress,

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unsustainable land subdivision, high cost of production, pests, and diseases (Daniel et al., 2021; Kogo et., 2021; Kwena et al., 2021; Santpoort, 2020). High variability of rainfall both within and between seasons across the region has caused uncertainty and large fluctuations in farmers' yield and income. Since maize is grown mainly under rain-fed conditions, it exposes the farmers to unpredictable weather patterns (Zhang et al., 2021). Climate change has become the greatest challenge in maize production in the country causing low and erratic rainfall (Wanyama et al., 2021). Over the past years prevalence of drought spells has increased resulting in poverty and from time-to-time total maize failure leading to chronic hunger and even deaths across the country (Mumo et al., 2021). To feed the rapidly growing population, therefore, smallholder farmers need to be productive using the existing limited land acreage by employing climate-smart agricultural (CSA) technologies. Therefore, scaling up climate-smart practices among farmers particularly smallholders is of key importance for sustainable maize production and improving food security in the country (FAO, 2018). CSA refers to an approach that sustainably increases productivity, enhances resilience (adaptation), reduces GHGs (mitigation) where possible, and enhances the achievement of food security and development goals) (FAO, 2010). Climate-smart agricultural practices include soil and water management, agroforestry, improved crop, and livestock farming targeted to sustainably increase production and reduce the emission of greenhouse gases (Midamba et al., 2023).

A lot of attention has been shifted towards the development of means and methods of sustaining crop production activities maize being among them in Kenya by promoting the use of climate-smart agriculture (CSA) among small-scale farmers through empowerment and capacity building (Esilaba, 2021; Chesterman & Neely, 2015; Franzel et al., 2019). The government of Kenya responded to the demands of farmers by initiating and partnering with international and local organizations to promote climate-smart agriculture in the country. Climate-smart agriculture addresses the risks that crop production faces under a changing climate, underscores agriculture's role in solving climate change and focuses on the importance of intensification of crop production required to feed a global population (FAO, 2018). Climate-smart agriculture practices are important to building resiliency and addressing climate change, they also tackle the essential questions of agricultural productivity (Nyang'au et al., 2021). This means getting the maximum maize yields out of land already under cultivation, so we don't go tearing out more carbon-rich forests to expand mediocre agricultural lands; however, increasing soil health and hyper-efficiently managing water improves yields and reduces the cost of inputs such as fertilizer and water (Obwocha et al., 2022). Small-scale maize farmers in Kenya are highly vulnerable to the impacts of climate change, due to their dependence on rain-fed agriculture for their livelihoods and location in marginal lands. According to Ochieng et al. (2020), risks to Kenya’s maize rain-fed farming system need to be proactively managed, promoting crop diversifications, addressing technology and management gaps in the face of the growing challenges of increased climatic variability and pressure from new pests and diseases.

Consequently, CSA and eco-friendly agricultural practices are vital to ensure food security through ensuring availability, sufficient maize production, accessibility to everyone and proper utilization in the right diversity and stability in Kenya particularly in Trans-Nzoia County. CSA aim at sustainable intensification, sound, and efficient management of natural resources, and offers an opportunity for climate change funding while seeking to strengthen the livelihoods of small-scale farmers through improved access to services, knowledge, genetic, financial resources and markets (Gupta & Hussain, 2022). The climate-smart approach aims at enhancing productivity and returns, improving adaptation of livelihoods and ecosystems, and

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reducing greenhouse gas emissions. The approach includes well-proven technologies that already exist and other innovative practices such as conservation agriculture; agroforestry; water harvesting and efficient use; use of varieties and breeds that can perform better under various climatic stresses; use of safety nets, risk insurance and timely climate information by farmers (Hlophe-Ginindza et al., 2021; Anuga et al., 2019). CSA practices such as the use of cover crops, rotation of crops, intercropping with legumes, water harvesting, irrigation, integrated nutrient management, contour farming, terracing, agroforestry, minimum tillage, and crop residue management showed stability in production and a significant increase in yield of crops both in the short and long run in humid and dry areas (Arif et al., 2020). The increase in yield is attributed to enhanced soil fertility, enhanced infiltration of water and water retention capacity, controlled soil erosion and improved soil structure (Beatrice et al., 2024). These practices as opposed to conventional practices require the use of low inputs and enhance soil carbon sequestration, a process that involves removal and storage of carbon from the atmosphere by soils. Improved pasture and grazing management enhance the quality of forage, which in turn increases the yield of livestock besides ensuring resilience to erratic weather patterns and effects of extreme weather events, particularly in dry areas (Ariom et al., 2022; Esilaba, 2021).

Despite the importance of CSA practices, it is not clear the influence of adoption and maize income particularly on small-scale farmers ‘income in Trans-Nzoia County, thus this study was set to fill this gap. There are insufficient empirical studies based on climate-smart agriculture practices that identify the climate-smart agriculture practices status and income in using the practices. Hence, to contribute to filling the research gap, this study identified the local climate-smart agriculture practices and adoption, and the status of maize productivity implication to income among farmers in Trans-Nzoia Kenya.

METHODOLOGY

Study Area

The study took place in Trans-Nzoia County which is one of the 47 Counties located in the North Rift region of Kenya. The County is located between the Nzoia River and Mount Elgon (Trans Nzoia County Government, 2018). The county lies between longitudes 0°52′and 1°18′N and latitudes 34°18′and 35°23′E. Trans-Nzoia County has five administrative sub-counties: Kwanza, Endebess, Saboti, Kiminini and Cherangany. The County covers an area of 2487 km2, of which about 2000 km^2 is arable land (Trans-Nzoia County Integrated Development Plan, 2017). The county population is approximately 990,000 people, according to the 2019 Kenya Population and Housing Census (KNBS, 2019). The rainfall pattern is bimodal, with long rains from April to June, while short rains from August to October and evenly distributed rainfall throughout the year with average annual rainfall ranges between 700 and 2100mm per annum, and the temperature range is between 11 and 25℃ (County Government of Trans-Nzoia County Integrated Development Plan 2018-2022, 2022). Agriculture is the leading economic activity in the County with maize being the largest crop being produced in the County (Trans- Nzoia County Government, 2018). Trans-Nzoia County was purposively selected because of its high potential for maize production.

Data Collection and Analysis

A cross-sectional survey design was used for the study. Both primary and secondary data sources. Secondary data was collected by reviewing different published and unpublished materials and documents. The study used both quantitative and qualitative tools. Smallholder farmers were drawn from the eight wards of the county and were interviewed using a semi-structured questionnaire. A further observation guide was used to collect data. The quantitative data was analysed using descriptive statistics, correlation, coefficient of

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variation and multiple regression analysis techniques. Whereas the qualitative data was analysed by narration and statement.

RESULTS AND DISCUSSIONS

Table 1 shows that the majority of respondents who were interviewed in the present study, were female 59.7 %. 57 % and 41 % of small-scale farmers were within 35-49 years and 50-64 years, 10 % were within 25-34 years, while only 3 % and 8 % those less than 24 years and above 64 years respectively.

Table 1: Demographic Characteristics of the Respondents

Variables	Category	Frequency (N)	Percent (%)
Gender	Male	48	40.3
	Female	71	59.7
Age	< 24	3	2.5
	25-34 years	10	8.4
	35-49 years	57	47.9
	50-64 years	41	34.5
	Above 64 years	8	6.7
Education level	No formal	12	10
	Primary	40	34
	Secondary	50	42
	Post-secondary	17	14
Income generating activities	Formal	7	6
	Business	12	10
	Casual	10	8
	Agriculture (Major crop-maize)	90	76

The finding shows that most of the small-scale farmers were in middle age. This could likely affect their output in maize production due to the limitation of their own physical energy, according to Guo et al. (2015) ageing farmers tend to abandon their land, reduce labour input to agricultural production and reduce land use rate, resulting in insufficient agricultural labour and land input, which has a negative impact on agricultural output. However, as farmers age they gain more experience in farming which leads to improvement in production. 12 % of the small-scale farmers had not attained any form of education.

This could affect their practices in agriculture and therefore production of maize. 40% had attained primary education, 50% had secondary education and 17 had attained post-secondary education. Education is important as it enhances the farming skills and productive capabilities of the farmer and enables them to follow some written instructions about the application of adequate and recommended climate-smart agriculture practices. In line with this Abate et al. (2019) stated in their study that education is a source of technical know-how and improvement of technical knowledge and the enhancement of labour efficiency in agriculture. Further Autio et al. (2021) stated that farmers lacking surplus land resources or investment capital have limited access to many of the climate change adaptation techniques. Analysis of the findings further shows that farmers obtained income from different sources with the majority (90%) depending on agriculture to earn an income with maize production being that key crop. This proves the important role that agriculture plays and is depended upon by farmers for their livelihoods in the region and in the country. The contribution of the agricultural sector towards poverty reduction has been realized to have a multiplier effect which is greater than the other sectors in the economy (FAO,2018).

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Table 2: Income from Maize Farming

Income (Ksh)	Frequency (N)	Percent (%)
1000-10000	83	70
10001-20000	30	25
20001-30000	6	5

The findings from Table 2 reveal that the majority (70%) of the small-scale farmers had received income between 1000 – 10000, 25% received an income of between 10001 – 20000, while 5% received an income between 20001 - 30000 from selling maize in the previous one year they had planted maize. This implies that the majority received low income with few receiving potential incomes. The analysis of the adoption of climate-smart agriculture practices on maize production, revealed that the practices were to a great extent averagely, fairly, and poorly adopted by the farmers which still points out the vulnerability of farmers to climate change. For the farmers to realize the required output from their maize farms' full adoption of climate-smart practices is required.

Table 3: Descriptive Statistics for Adoption of Climate-Smart Practices

CSA practices	Frequency (N)	Percent (%)
Use of organic fertilizers	30	25
Changing crop planting dates	14	12
Crop and livestock diversification	55	46
Practice of irrigation	16	13
Use of agro weather advisories forecasts	68	56
Agroforestry	47	39
Crop rotation	106	89
Drought-tolerant crop varieties	55	46
Intercropping	88	74
Minimal tillage	85	71
Timely planting	37	31
Planting of cover crops	37	31
Improved livestock feed and feeding practices	68	57
Integrated soil fertility management,	42	35
Crop residue management,	20	17
Water harvesting	70	59
Soil conservation structures	30	25
Water conservation structures	53	45
Mixed cropping	56	47
Farm Insurance	27	23
Early maturing varieties	40	34
Pests and disease-resistant crop varieties	43	36

In terms of climate-smart agriculture practices found in the study area, findings indicate that some of the practices such as crop rotation, minimal tillage, and intercropping were highly adopted by the farmers; this is so because the results show that 89 % of the respondents adopted crop rotation, 71% adopted minimal tillage and 74% adopted intercropping practices. Average practices such as water harvesting, improved livestock feed and feeding practices and use of agro weather advisories

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forecasts were adopted by the small-scale farmers. Climate-smart agriculture practices including pests and disease-resistant crop varieties, early maturing varieties, farm insurance, mixed cropping, water conservation structures, soil conservation structures, integrated soil fertility management, planting cover crops, timely planting, drought tolerant crop varieties, use of organic fertilizers, agroforestry, crop and livestock diversification were fairly adopted by farmers. The practice of irrigation (13%), changing crop planting dates (12%) and crop residue management (17%) were poorly adopted by the farmers.

The results concur with that of Kurgat et al. (2020) that most of the climate-smart agricultural practices and technologies identified have low to medium on farm adoption rates, despite their potential benefits to adaptation, productivity increase and mitigation efforts. The results on fairly and poorly adoption of some climate-smart agricultural practices implied that small-scale maize farmers remained vulnerable to climate change to some extent which affects their maize production. Climate change has been defined as most concerns of today's world and has greatly reshaped or is in the process of altering production and affecting farmers' production with vulnerability becoming extreme in the world and Kenya in particular (Karimi et al., 2018). Therefore, to mitigate the impact of climate change, farmers must adopt climate-smart agricultural practices available at their disposal. Climate-smart agriculture practices increase productivity, farmers resilience, reduces or removes GHGs, therefore, transforming and reorienting agricultural development under the new realities of climate change (Alliance, 2018). Fair and poor adoption of climate-smart agricultural practices could be attributed to factors like financial constraints which hinder them from implementing some of the CSA technologies which are expensive.

Additionally, factors of age, education, and gender could be the reason for fairly and poorly CSA practices adoption (Lan et al., 2018; Nyasimi et al., 2017). For instance, educated farmers adopt more likely agricultural adaptation practices since they tend to be more aware of climate change and the agricultural innovations available. Farmers' marital status, the number of dependents, farming experience, the headship of the household, and access to a phone have been reported to influence the rate of adoption of CSA (Jellason et al., 2021; Nkonya & Koo, 2017).

Multiple choices were provided to identify the type of Climate-smart Agricultural practices farmers have been adopting in the area for the last year they planted maize. Their responses were analysed using multiple response analysis techniques and the results are displayed in Table 4. Multiple regression analysis was conducted to determine if the adoption of climate-smart agricultural practices was a significant predictor of income. The analysis revealed that a combination of climate-smart agricultural practices explained a significant variation in the income, [R^2 = 0.342,]. Specifically, the adoption of climate-smart agricultural practices accounted for 34.2 % of the variance in income and this shows that climate-smart agricultural practices had a medium effect on the income.

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Table 4: Effects of Climate-smart Agricultural Practices on Maize Income

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	2.002	0.716		2.796	0.006
Practice of irrigation	0.281	0.137	-0.196	2.058	0.042
Early maturing varieties	0.202	0.105	-0.194	1.914	0.000
Use of organic fertilizers	0.259	0.104	-0.230	2.499	0.014
Farm Insurance	0.016	0.117	0.013	0.134	0.894
Crop rotation	0.013	0.144	-0.008	0.088	0.000
Pests and disease-resistant crop varieties	0.046	0.113	0.045	0.410	0.682
Intercropping	-0.131	0.121	-0.117	-1.090	0.279
Use of agro weather advisories forecasts	0.019	0.103	0.019	0.185	0.854
Improved livestock feed and feeding practices	0.019	0.102	0.019	0.182	0.856
Planting of cover crops	0.103	0.108	0.097	0.951	0.344
Timely planting	0.073	0.114	0.069	0.643	0.022
Drought-tolerant crop varieties	0.172	0.100	-0.174	1.721	0.008
Agroforestry	0.289	0.100	0.288	2.904	0.005
Integrated soil fertility management	0.292	0.104	0.284	2.811	0.006
Minimal tillage	0.336	0.105	0.310	3.194	0.000
Crop and livestock diversification	0.038	0.090	0.042	0.419	0.676
Changing crop planting dates	-0.094	0.205	-0.062	-0.458	0.648
Crop residue management	0.104	0.173	0.079	0.601	0.550
Water harvesting	0.320	0.102	-0.320	3.128	0.002
Soil conservation structures	-0.186	0.111	-0.165	-1.675	0.097
Mixed cropping	-0.041	0.103	-0.042	-0.396	0.693
Water conservation structures	0.182	0.108	0.184	1.674	0.000

a. Dependent Variable: Income of the farmer

It was found (Table 4) that water conservation structures (p = 0.000), water harvesting (p = 0.002), minimum tillage (p = 0.000), integrated soil fertility management (p = 0.006), agroforestry (p = 0.005), drought tolerant crop varieties (p = 0.008), timely planting (p = 0.022), use of organic fertilizers (p = 0.014), crop rotation (p = 0.000), early maturing varieties (p = 0.000) and practice of irrigation (p = 0.042) significantly predicted influence farmers' income. However, mixed cropping (p = 0.683), soil conservation structures (p = 0.097), crop residue management (p = 0.550), changing crop planting dates (p = 0.648), crop and livestock diversification (p = 0.676), planting of cover crops (p = 0.344), improved livestock feed and feeding practices (p = 0.856), use of agro weather advisories forecasts (p = 0.854), intercropping (p = 0.279), pests and disease resistant crop varieties (p = 0.682), and farm Insurance (p = 0.894) were not significant predictors. This could be attributed to the low adoption of these practices by farmers which leads to not gaining the full impact of a practice which brings about the effect leading to increased productivity therefore income.

The significant influence of water conservation structures, water harvesting, minimum tillage, integrated soil fertility management, agroforestry, drought tolerant crop varieties, timely planting, use of organic fertilizers, crop rotation, early maturing varieties and practice of irrigation is in agreement with a study by Alela et al. (2024) who found out that agroforestry components can increase the capacity of seasonal crops to tolerate drought and thus support farmer's food security by avoiding total crop failure in the farm and increased crop

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productivity and income. Adopting agroforestry trees among farmers leads to multiple anticipated benefits, including improved soil carbon sequestration, food security and increased income for farmers. A study by Matita et al. (2022) demonstrates the important contribution of the use of organic fertilizers and drought-tolerant crop varieties in improving smallholder farmer livelihoods in Malawi. Turyasingura and Chavula (2022) maintained that crop rotation helps to keep soil nutrients and moisture in check and reduces the danger of pests and diseases by improving soil fertility leguminous crops fix nitrogen in the soil therefore reducing the use of nitrogenous fertilizer by farmers leading to increase yield and income.

Minimum tillage substitute labour and reduces the cost of cultivation with incremental effect in yield and income of small-scale and commercial farmers, conserves soil health with minimal disturbance in soil structure, porosity, and microbial growth, ensures spatial nutrient management and moisture retention in the root zone causing luxuriant plant growth with higher tillers (Tesfaye et al., 2021). Integrated soil fertility management, agroforestry and crop rotation enable farmers to improve production through improving soil fertility and minimise the build-up of crop-specific pests and diseases in the soil which increase production therefore more income to the farmers (Alela et al., 2024). Practices such as early maturing varieties, practising irrigation, and residue incorporation can improve crop yields, water and nutrient use efficiency and reduce GHG emissions from the agricultural fields; this will lead to more production and thus increase income among farmers.

Insignificant results from practices such as mixed cropping, soil conservation structures, crop residue management, changing crop planting dates, crop and livestock diversification, planting of cover crops, improved livestock feed and feeding practices, use of agro weather advisories forecasts, intercropping, pests and disease resistant crop varieties and farm Insurance and income disagrees with a study by Ighodaro et al. (2020) who stated that soil conservation structures improve soil quality, farm yield and productivity which leads to income increase. The use of agro weather advisory forecasts helps small-scale farmers to know when it will rain, the period it will last and also the amount of rainfall; this therefore will guide farmers in preparing for planting, leading to proper timing for the increased production therefore increase income (Manjappa and Yeledalli, 2013). It has also been reported that planting cover crops preserves soil moisture (water retention) and soil fertility through the accumulation of organic matter, maintains and/or improves soil carbon stocks and therefore contributes to product diversity and boosts yields hence increasing farmers' income.

CONCLUSIONS AND RECOMMENDATION

This study assessed the nexus between climate-smart agricultural practices and farmers’ income in Trans-Nzioia County. The econometric results showed that climate-smart agricultural practices such as water conservation structures, water harvesting, minimum tillage, integrated soil fertility management, agroforestry, drought tolerant crop varieties, timely planting, use of organic fertilizers, crop rotation, early maturing varieties and practice of irrigation were found to significantly influence income among small-scale maize farmers in Trans-Nzoia County, Kenya. Therefore, initiatives to promote climate-smart agriculture practices among small-scale farmers certainly add value in achieving the livelihoods of farmers through increased income. This study recommends that:-

- Farmers should ensure that they adapt greatly to climate-smart agriculture to increase productivity and therefore improve income.
- The extension agents should train farmers on the benefits of the adoption of CSA. This will increase the adoption rate and hence high income.

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- Subsidizing CSA inputs such as fertilizers can increase the adoption rate. Thus, this study recommends that the government should subsidize the prices of farm inputs.

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